Low energy requirements in an artiodactyl family: the case of the camelids

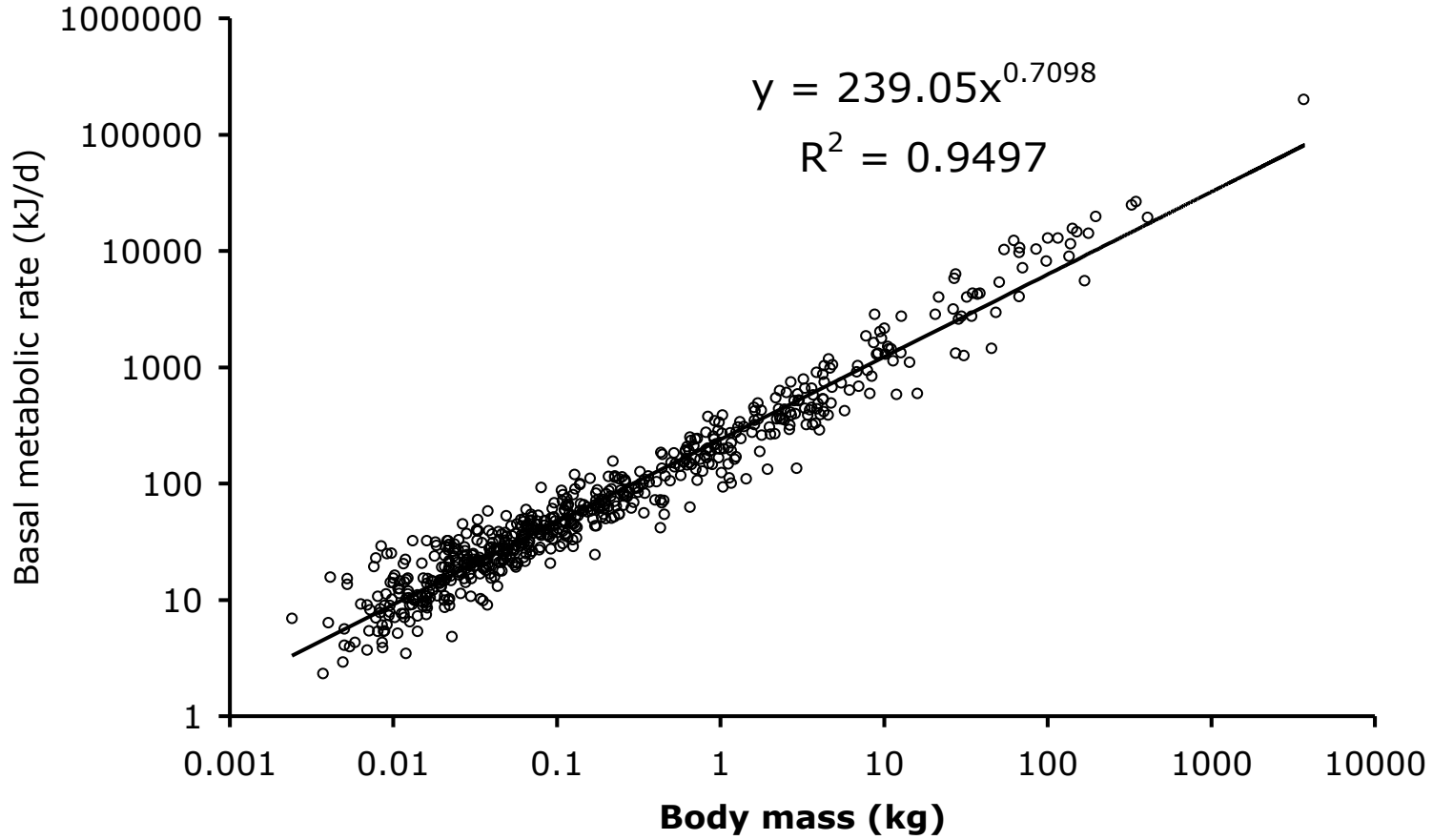
M.T. Dittmann[1,2], J. Hummel[3], U. Runge[4], C. Galeffi[5], M. Kreuzer[2], M. Clauss[1]

Clinic for Zoo Animals, Exotic Pets and Wildlife, Univ. of Zurich, Switzerland[1],
ETH Zurich, Institute of Agricultural Sciences, Switzerland[2],
Department of Animal Sciences, Univ. of Göttingen, Germany[3],
Kamelhof Olmerswil, Switzerland[4], Zurich Zoo, Switzerland[5]

University of Zurich[UZH]

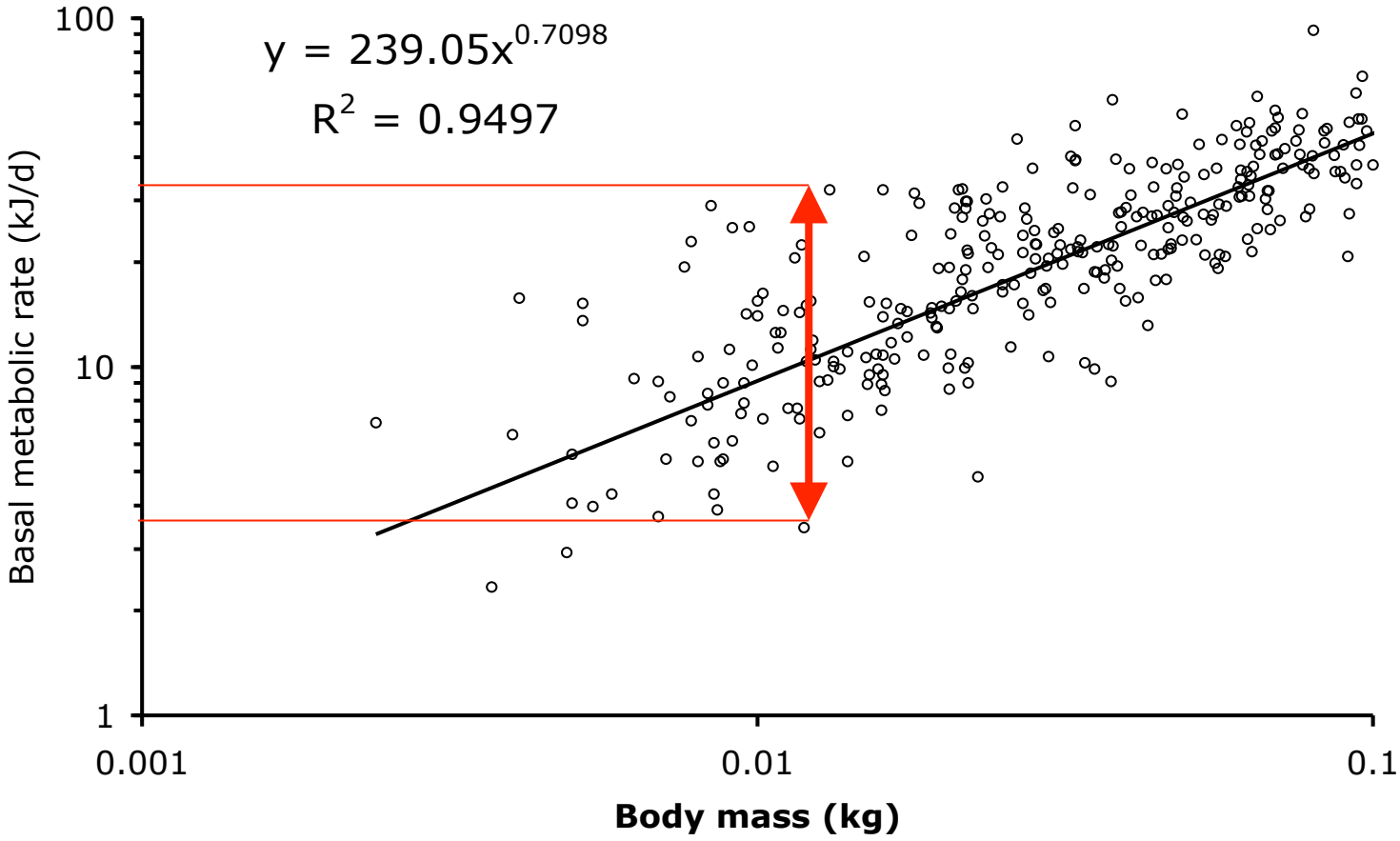
Clinic of Zoo Animals, Exotic Pets and Wildlife

Level of metabolism



Data from Savage et al. (2004)

Level of metabolism



Data from Savage et al. (2004)

Level of metabolism

Reasons for systematic variation in the level of mammalian metabolism:

- habitat
  - arctic vs. tropic
  - marine vs. terrestrial
  - ground vs. subterranean

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- habitat
  - arctic vs. tropic
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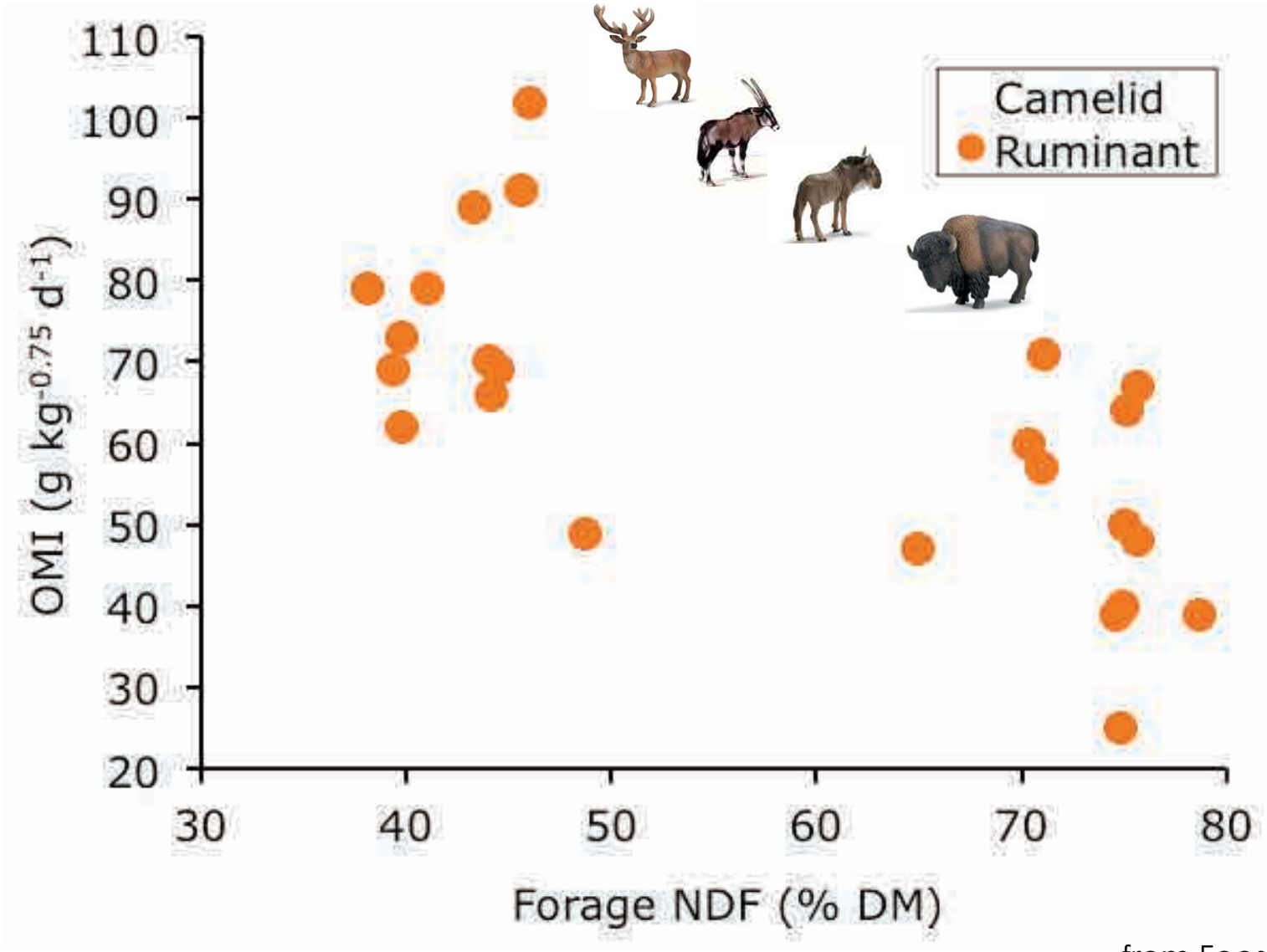
- phylogeny
  - marsupials vs. eutheria
  - xenarthra vs. other eutheria
  - camelids ? (vs. ruminants)

Presumptive evidence I: food intake



from Foose (1982)

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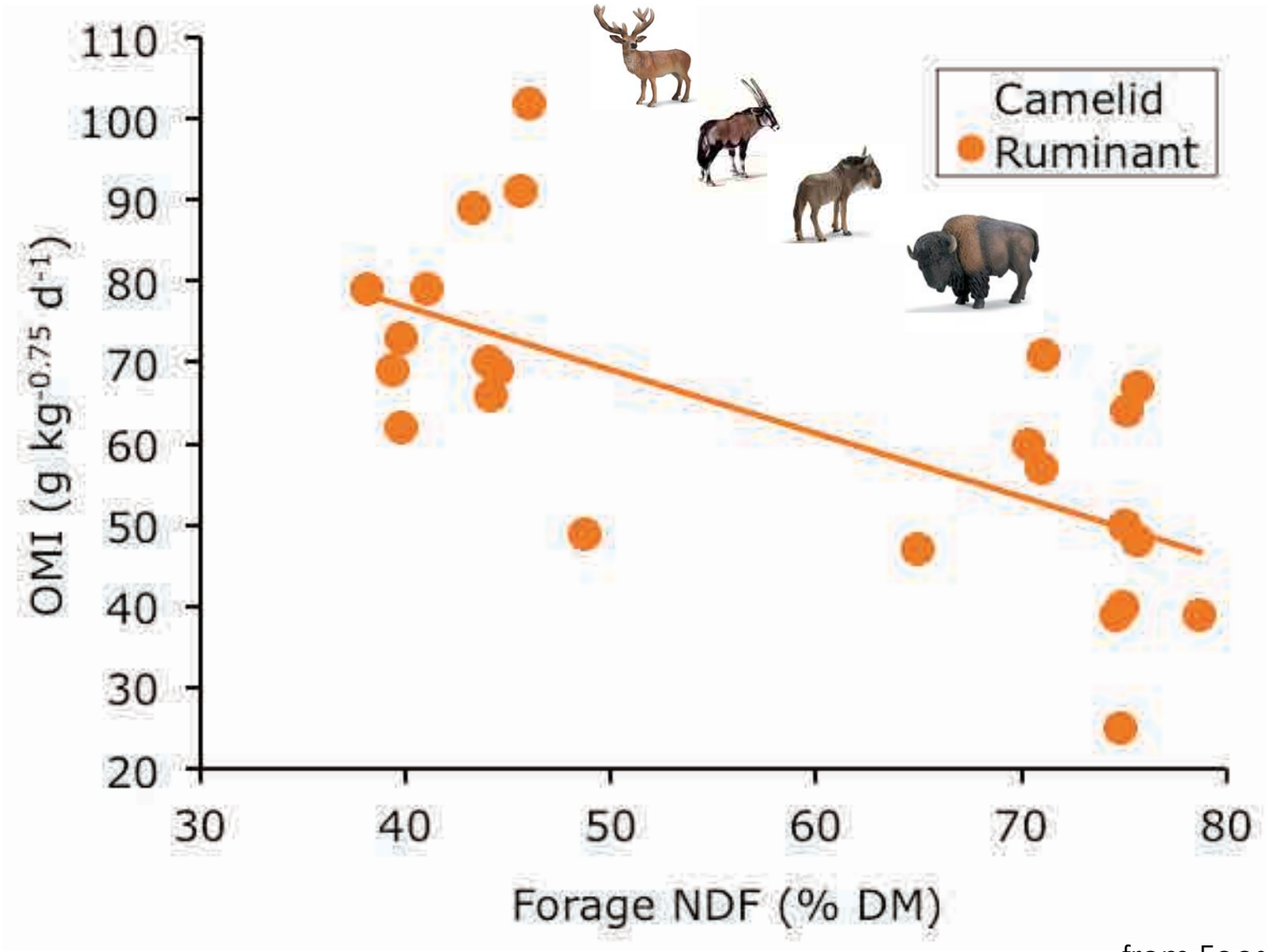

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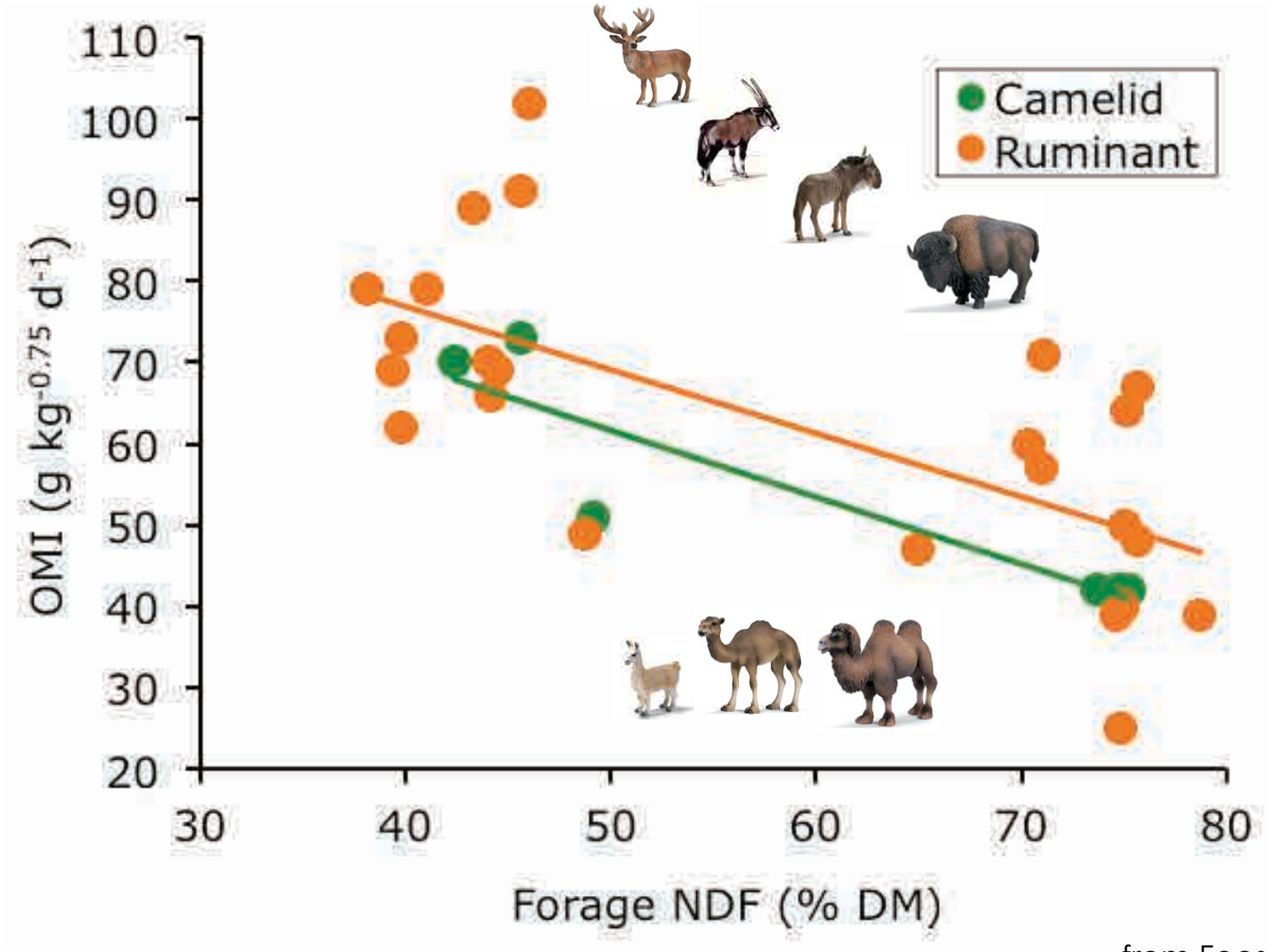

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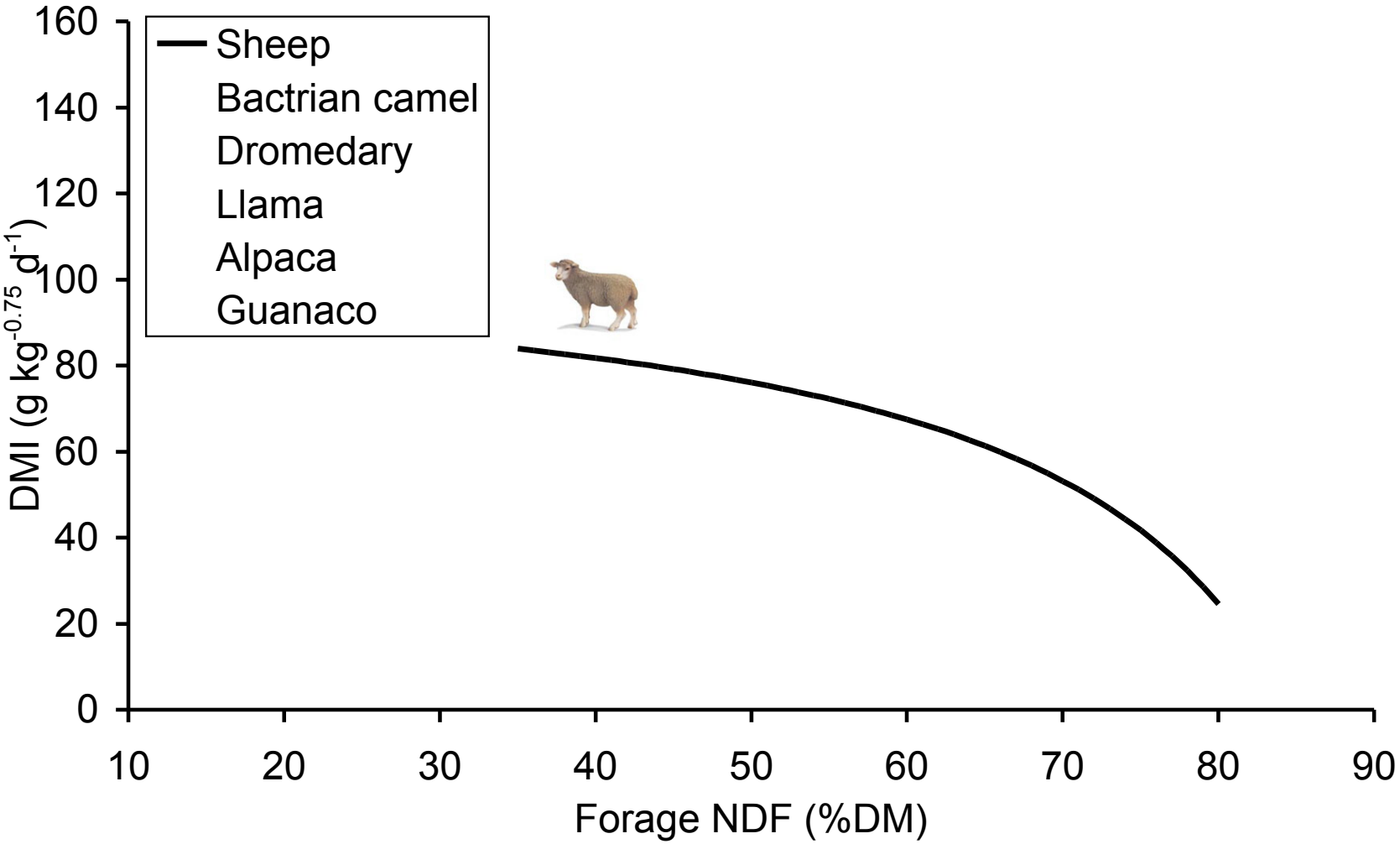

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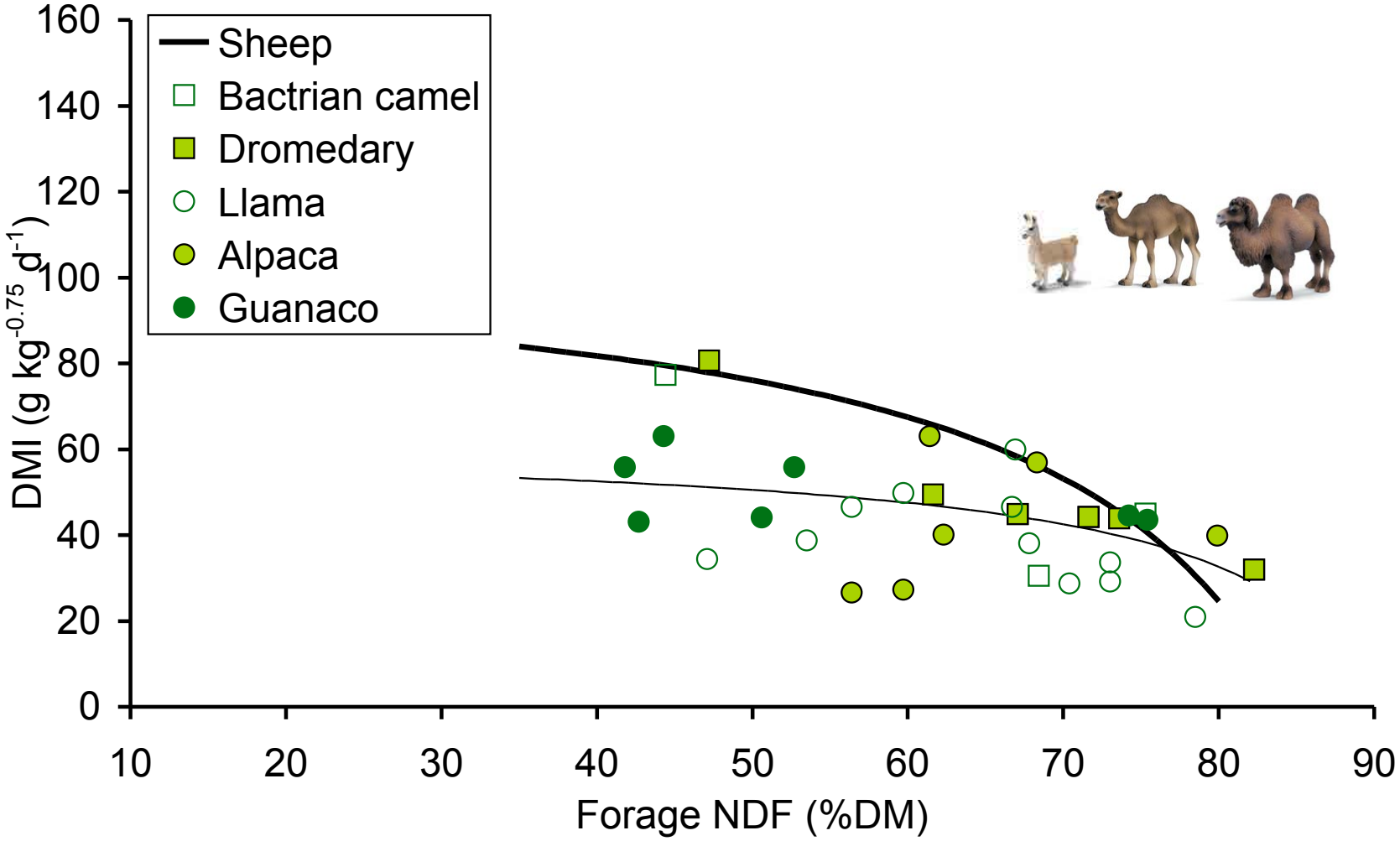

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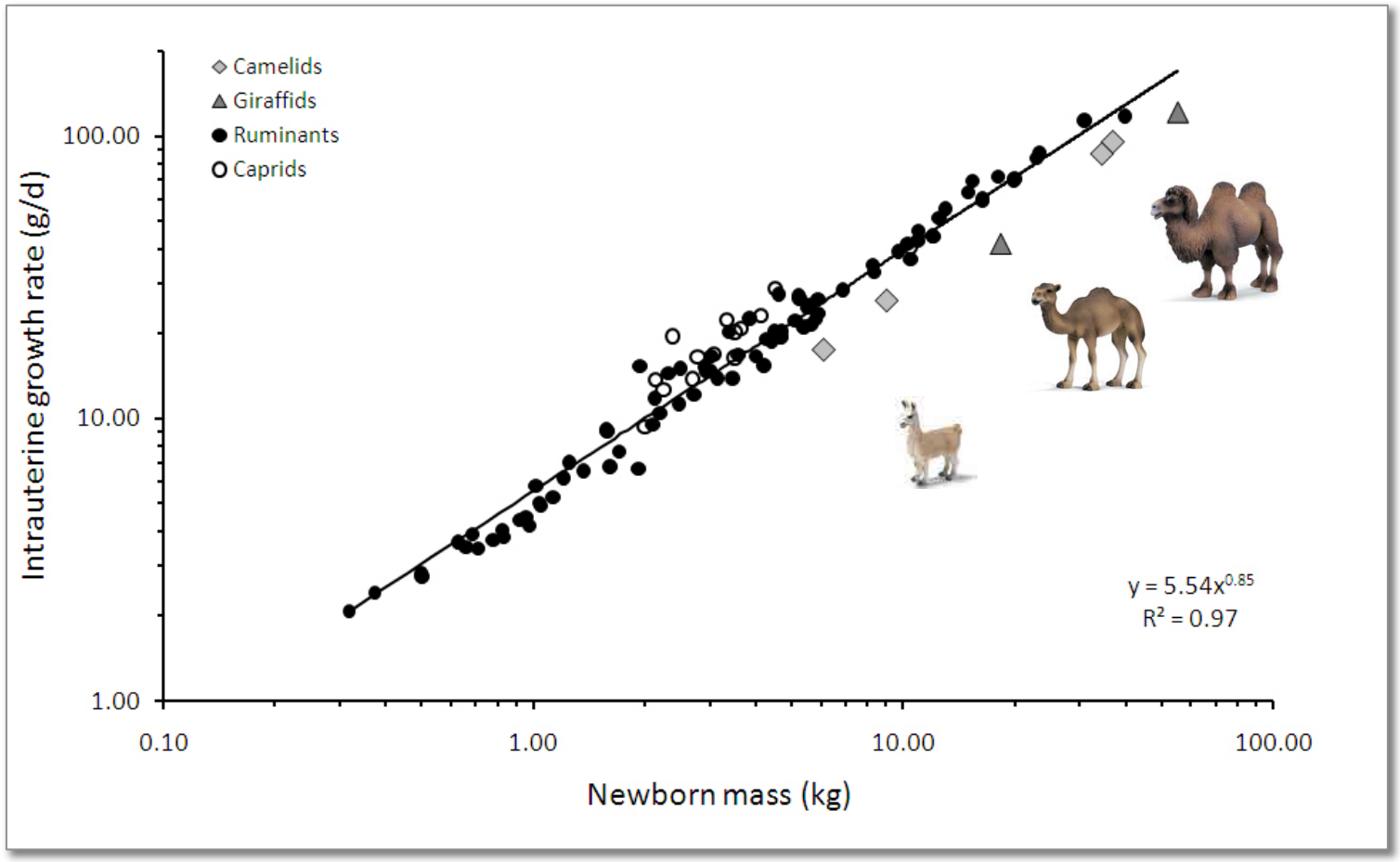
Presumptive evidence II: life history



from Müller et al. (2011)

Presumptive evidence III: fossil sequence

Historical Biology, 1994, Vol. 8, pp. 15–29
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MODELLING EQUID/RUMINANT COMPETITION IN THE FOSSIL RECORD

CHRISTINE M. JANIS[1], IAIN J. GORDON[2] and ANDREW W. ILLIUS[3]

[1]*Department of Ecology and Evolutionary Biology, Brown University, Providence, Rhode Island 02912, USA*
[2]*Macaulay Land Use Research Institute, Craigiebuckler, Aberdeen AB9 2QY, UK*
[3]*School of Agriculture, University of Edinburgh, West Mains Road, Edinburgh EH9, 3JG, UK*

(Received November 2, 1993)

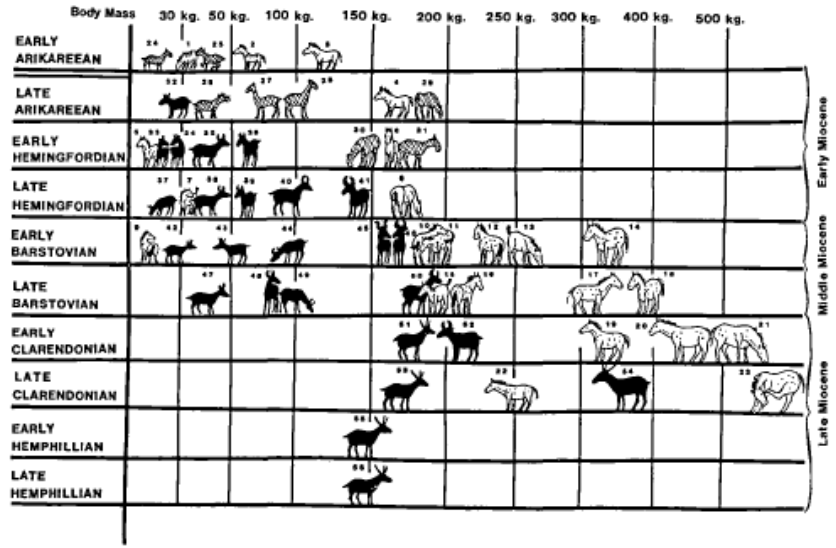

Figure 3 Body size distribution of browsing Miocene equids and ruminants. Key to ungulate taxa: A. Color of taxon: Striped horses=Mesohippines; white horses=Anchitherines; spotted horses=Hypohippines; black artiodactyls=Pecorans; cross-hatched artiodactyls=Tylopods.

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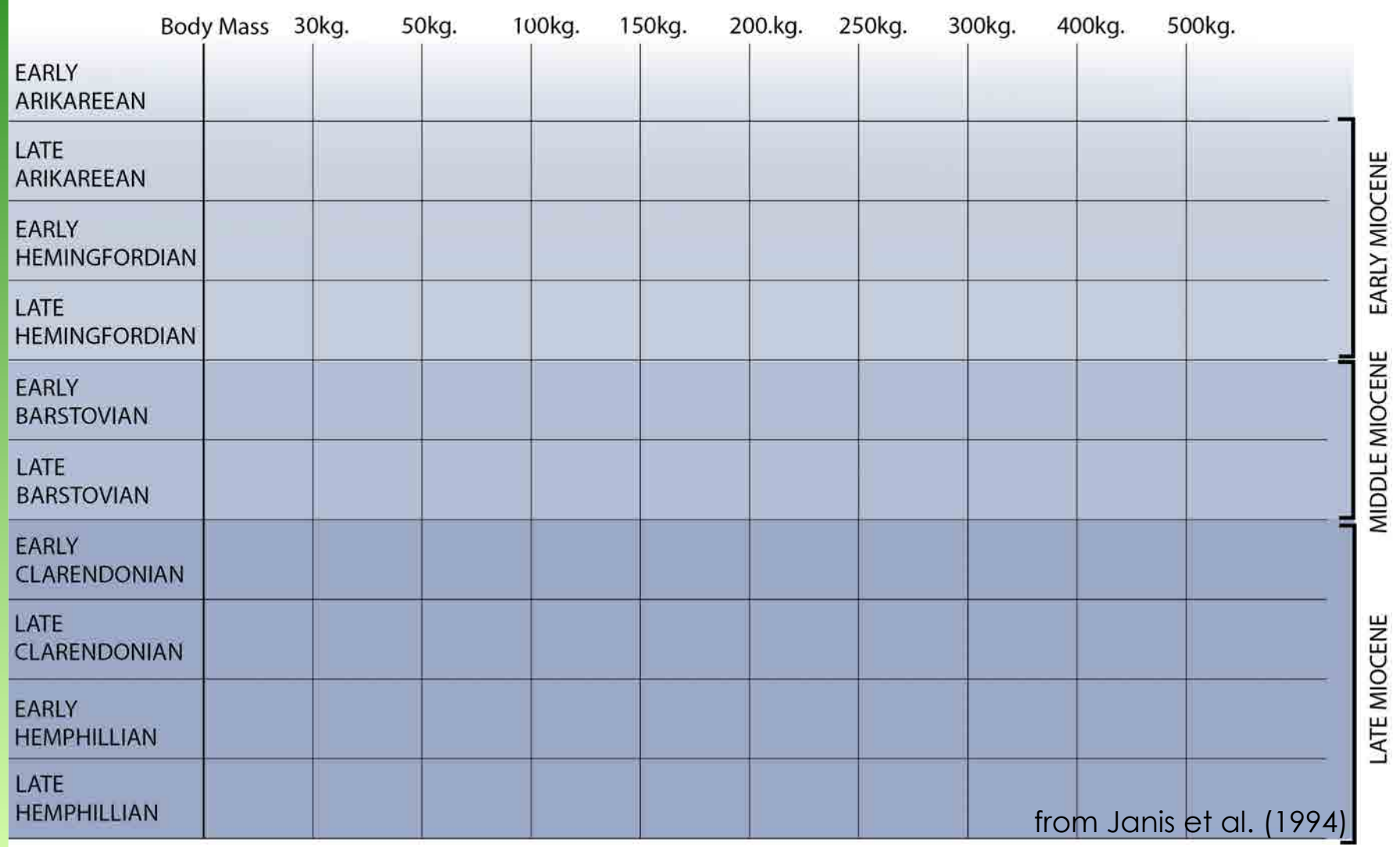

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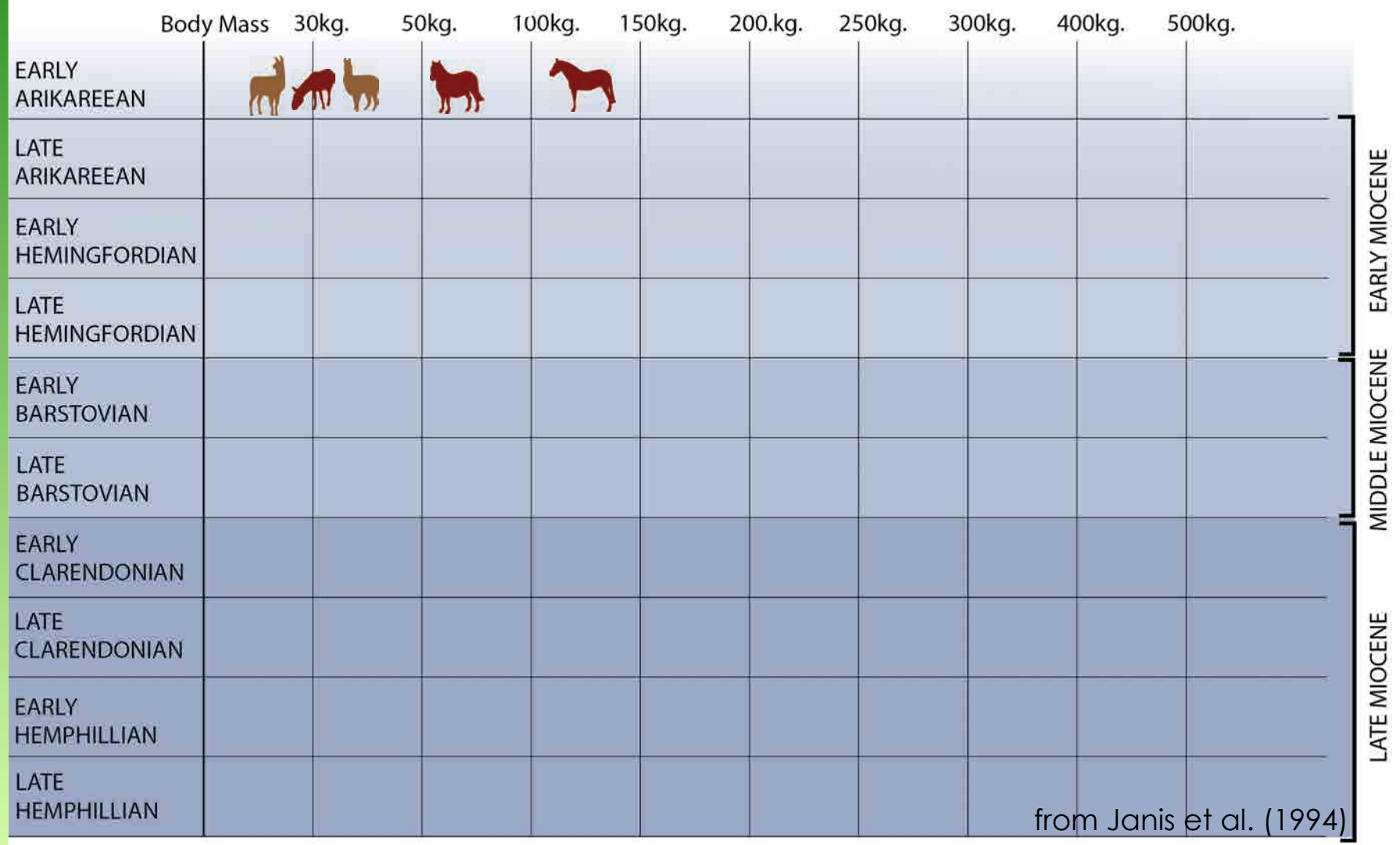

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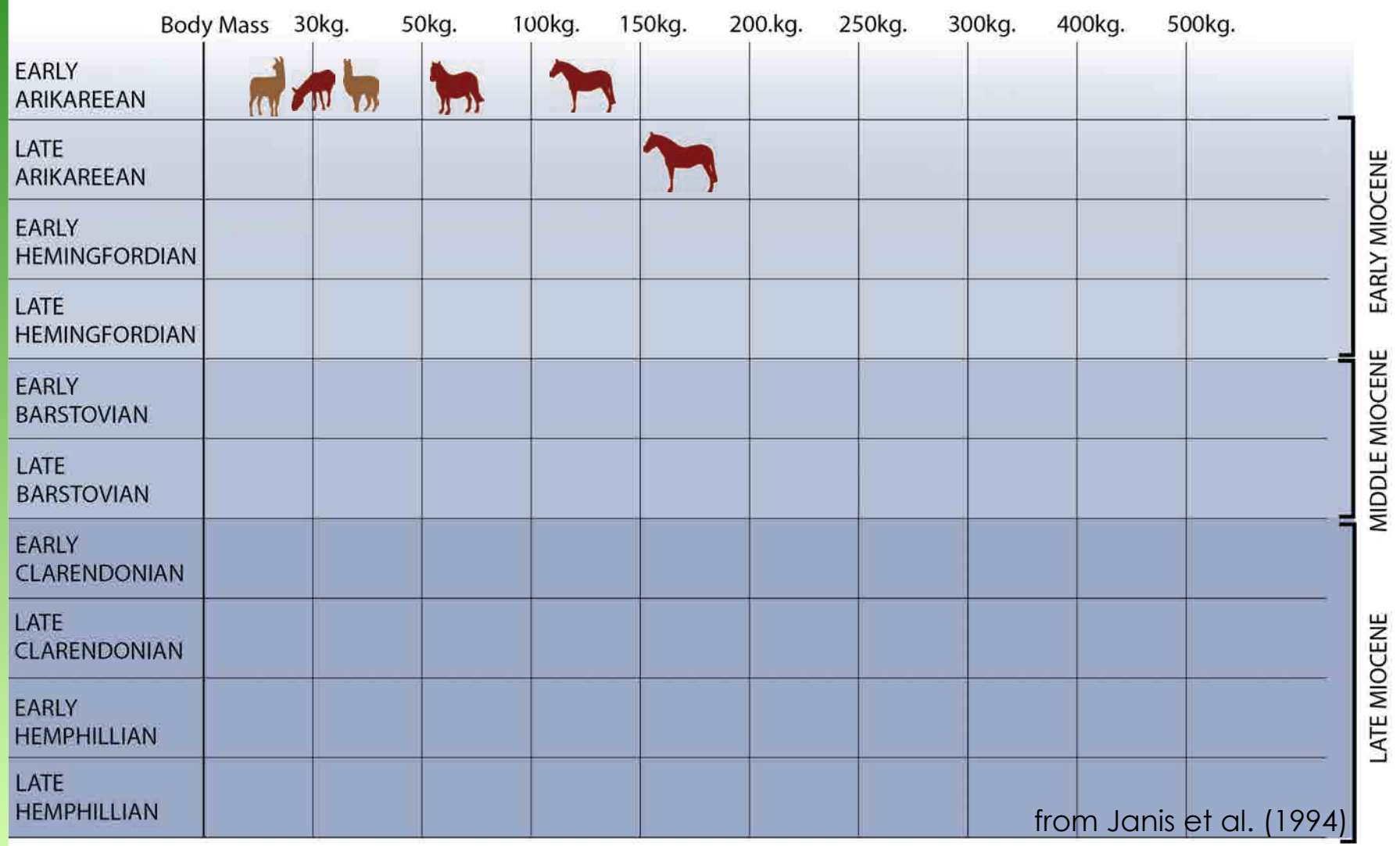

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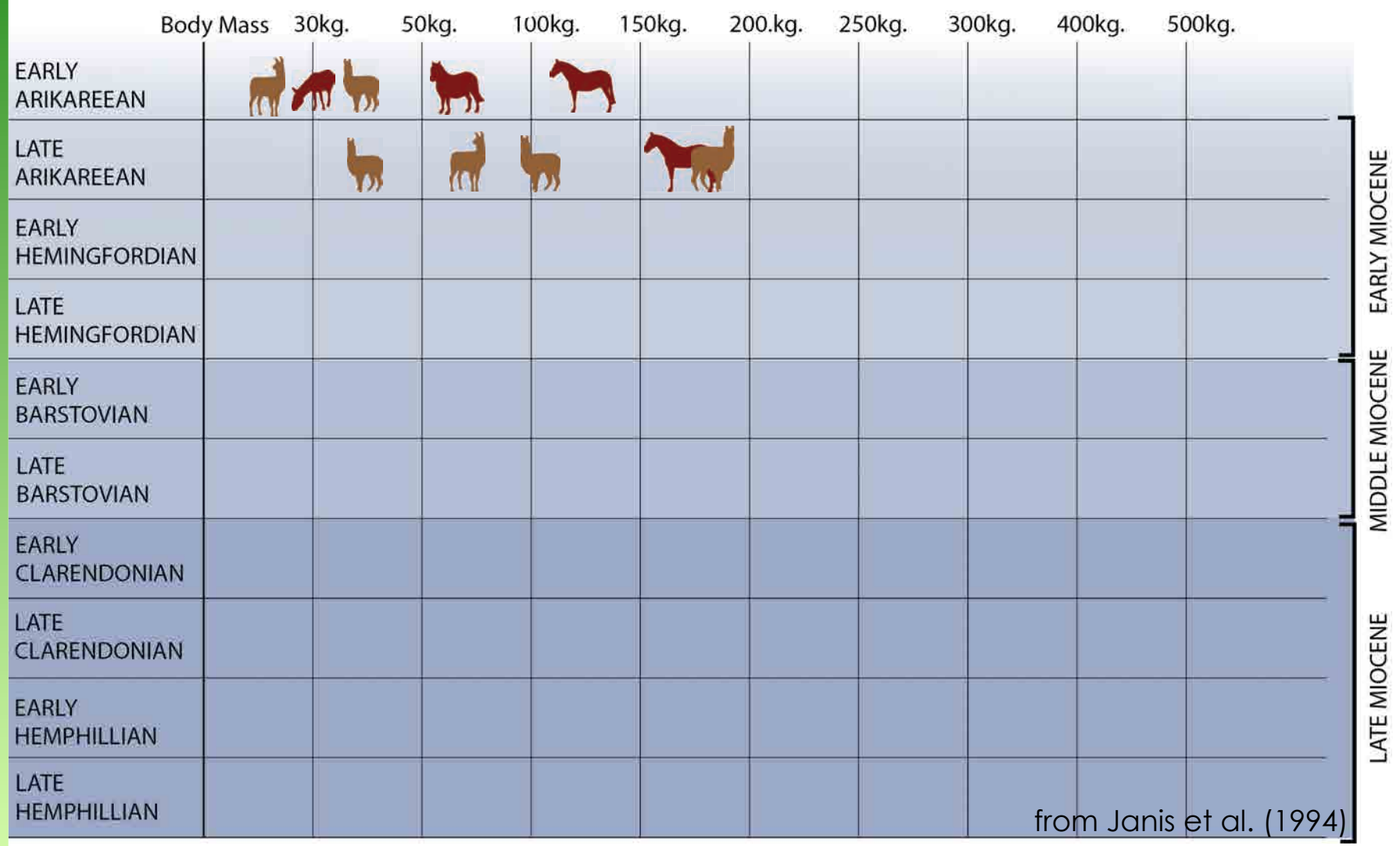

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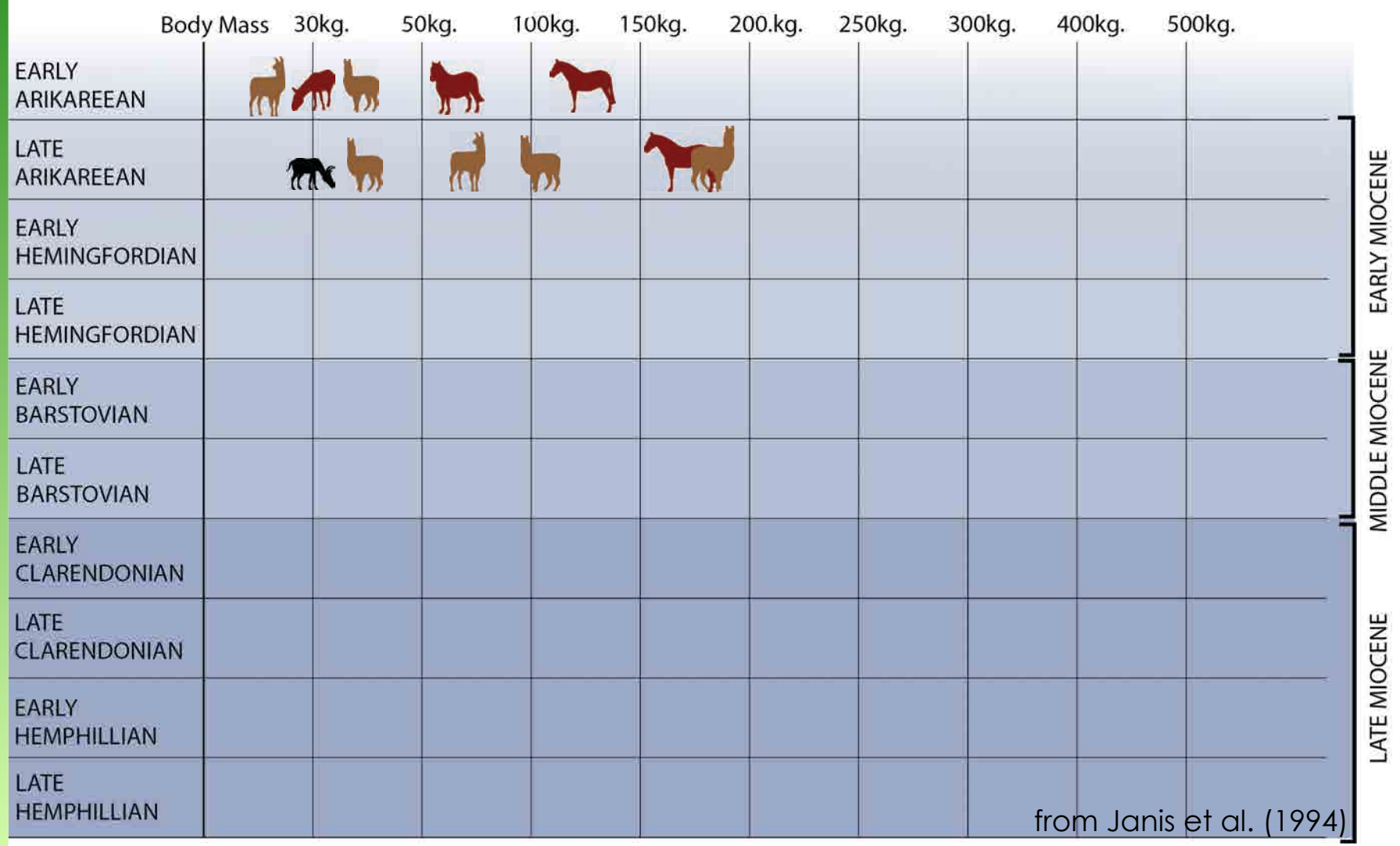

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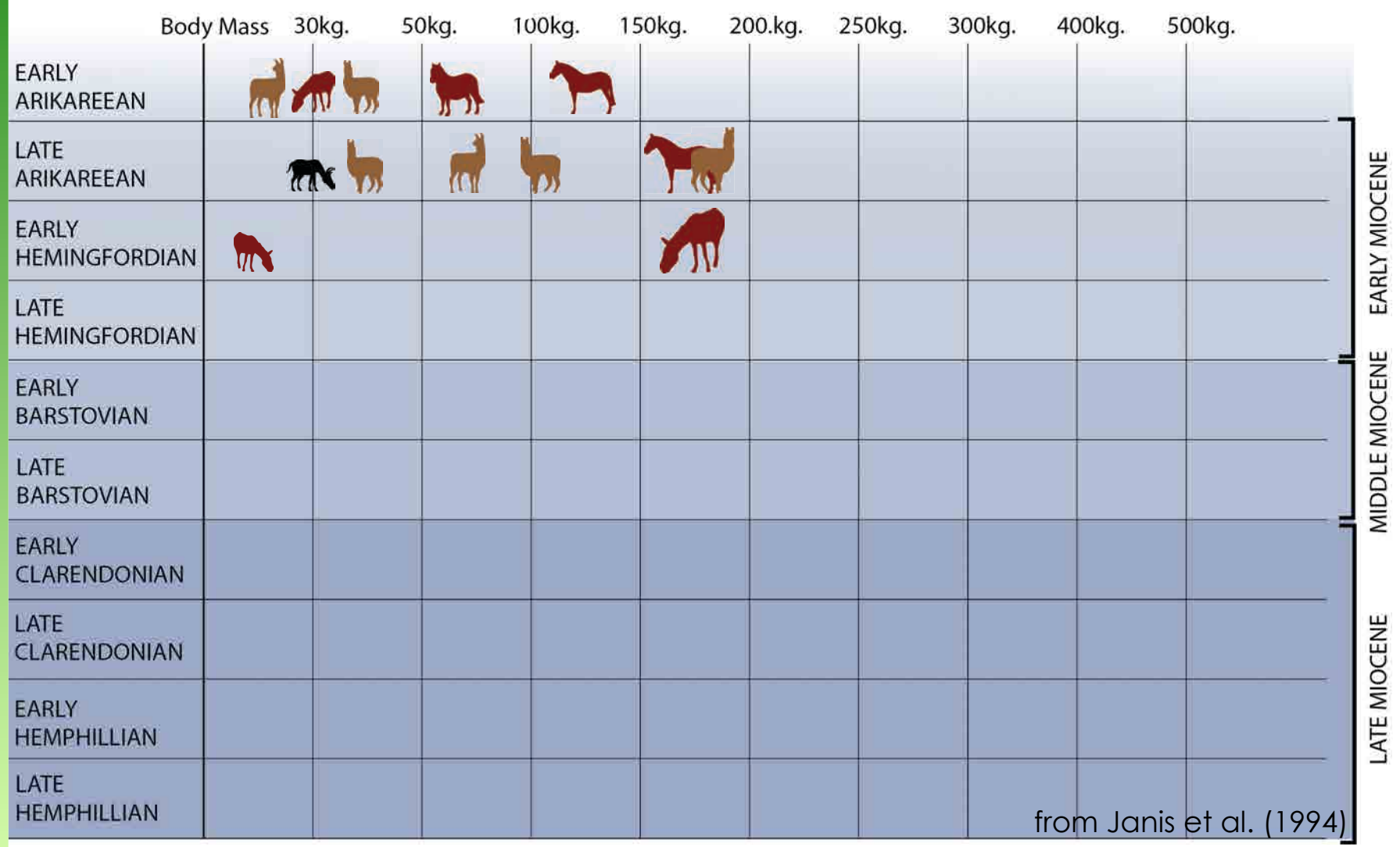

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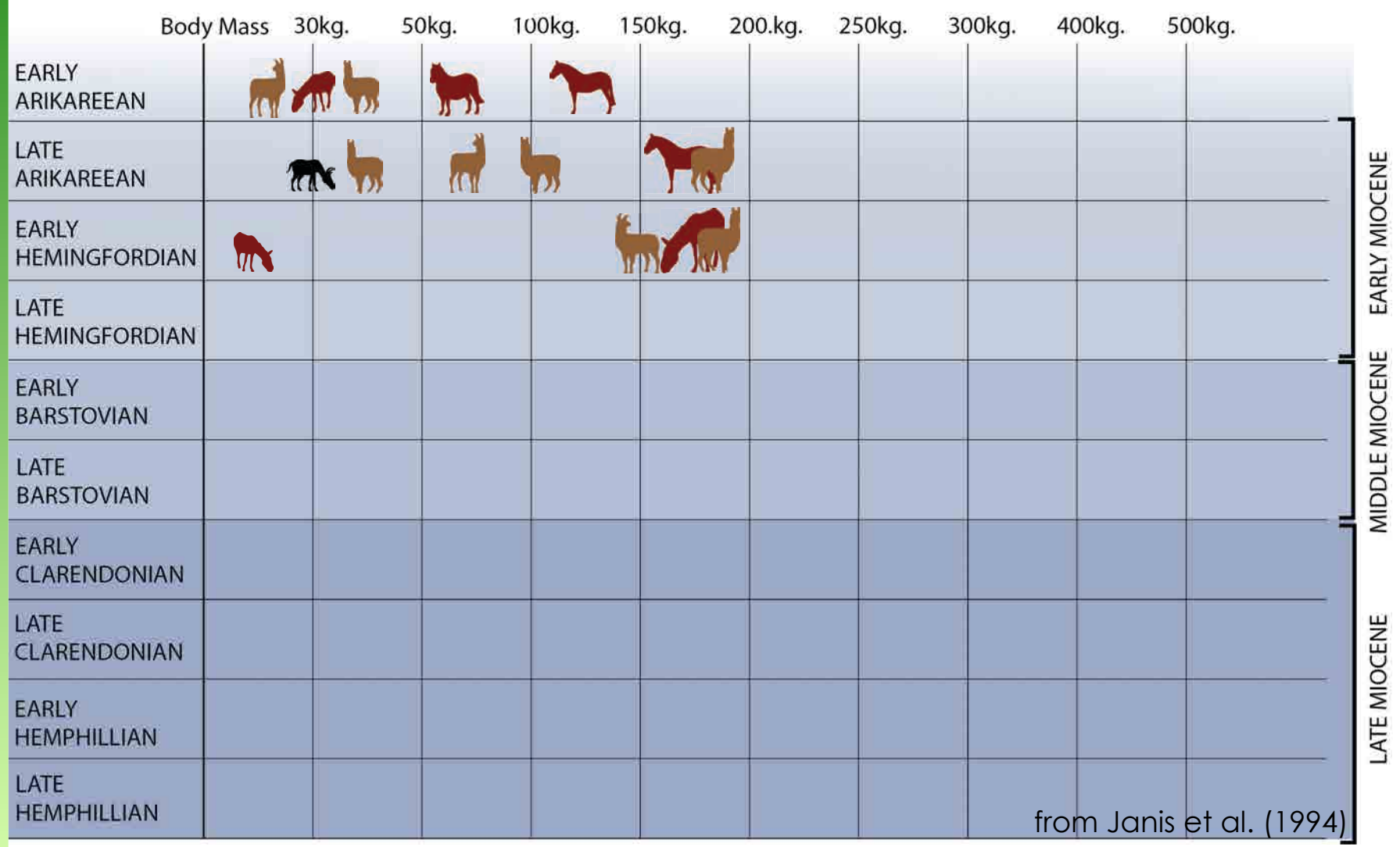

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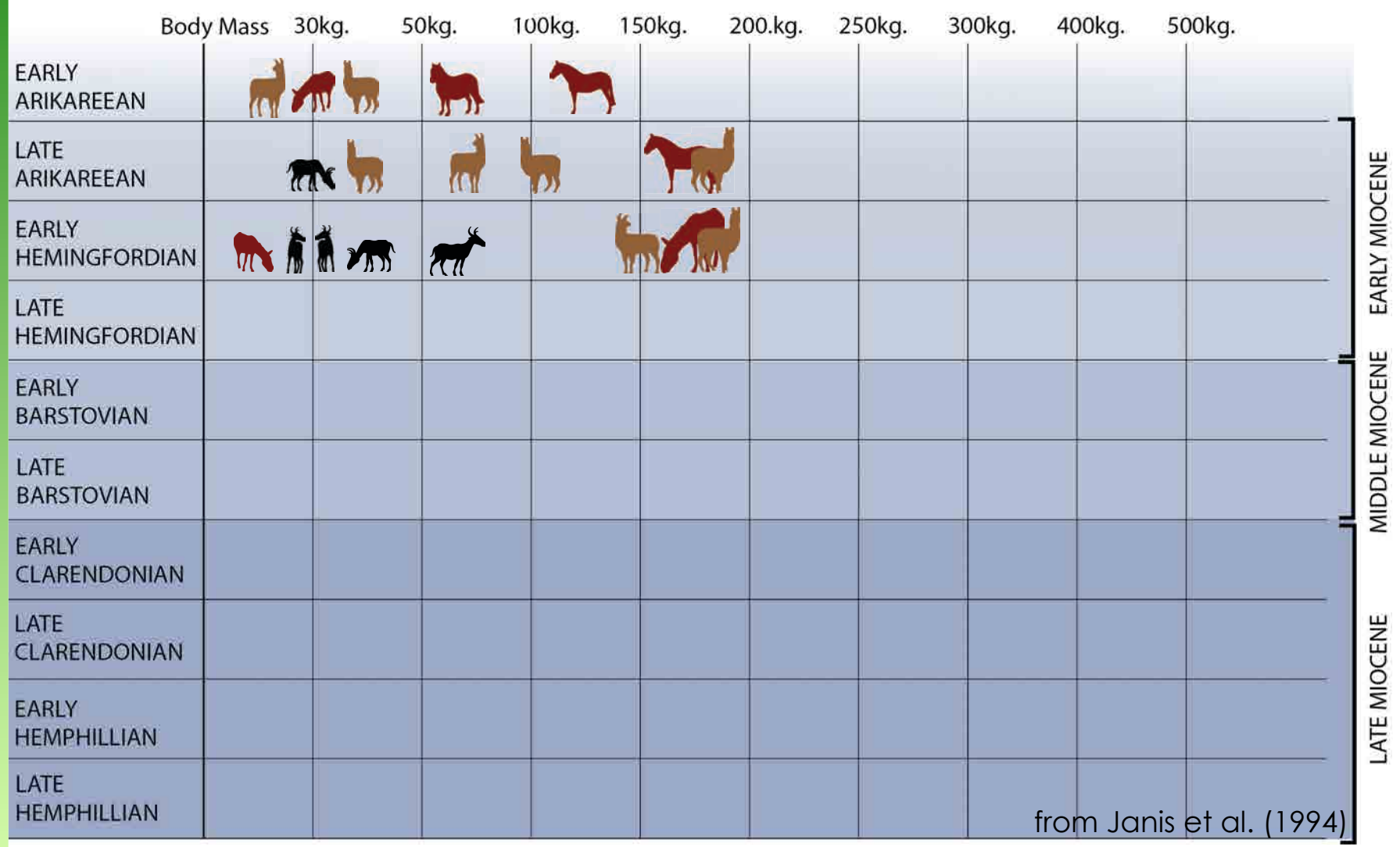

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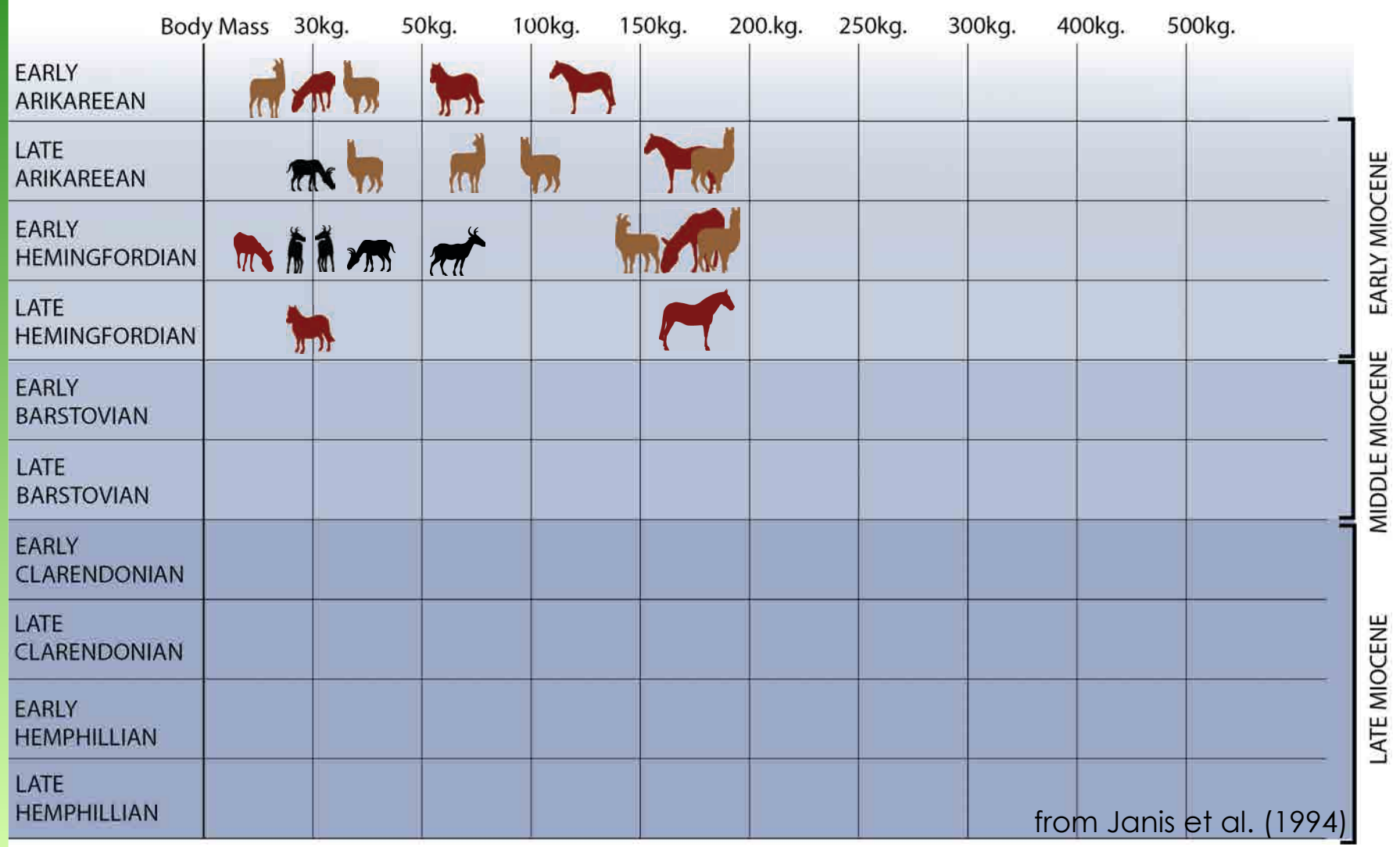

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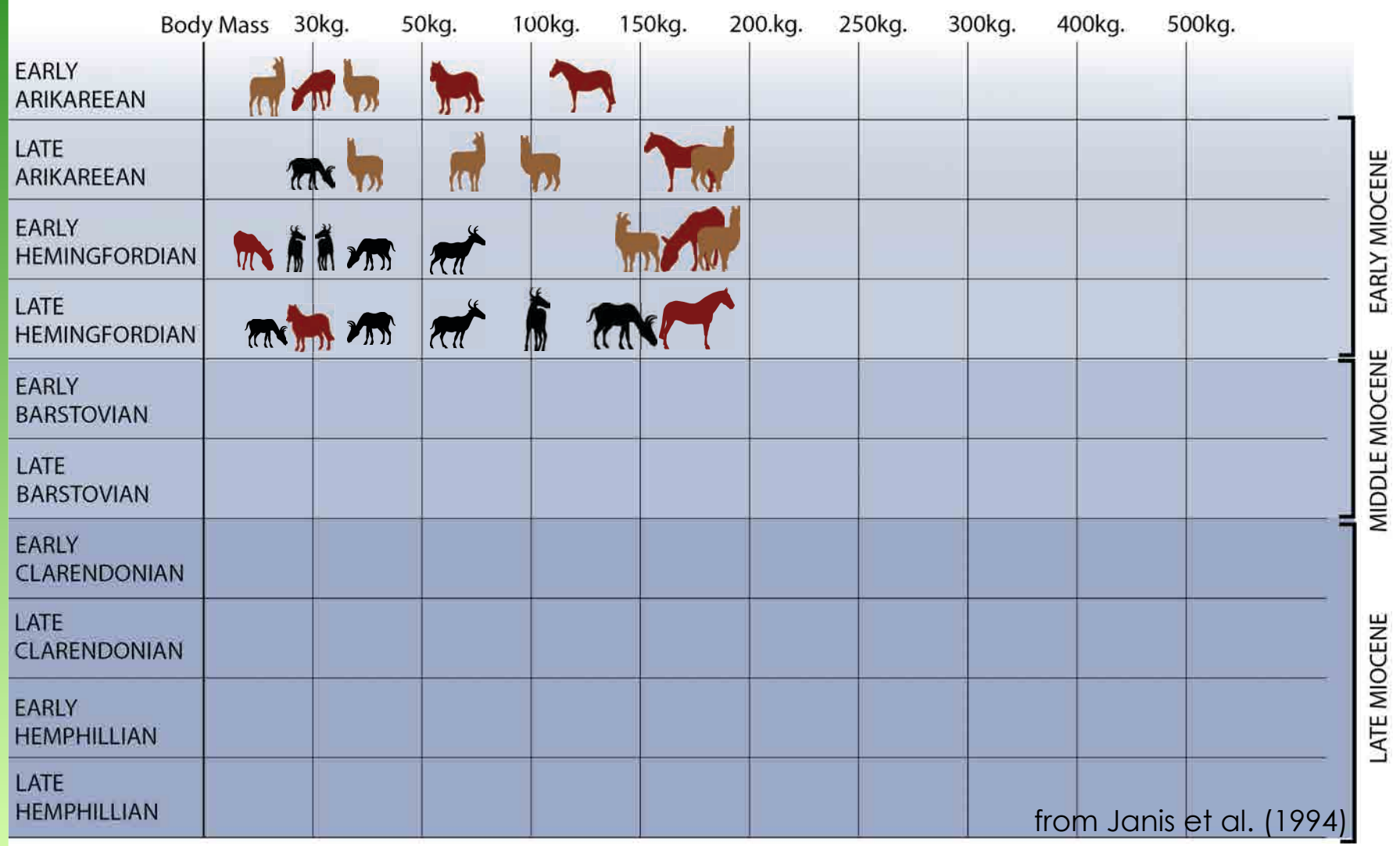

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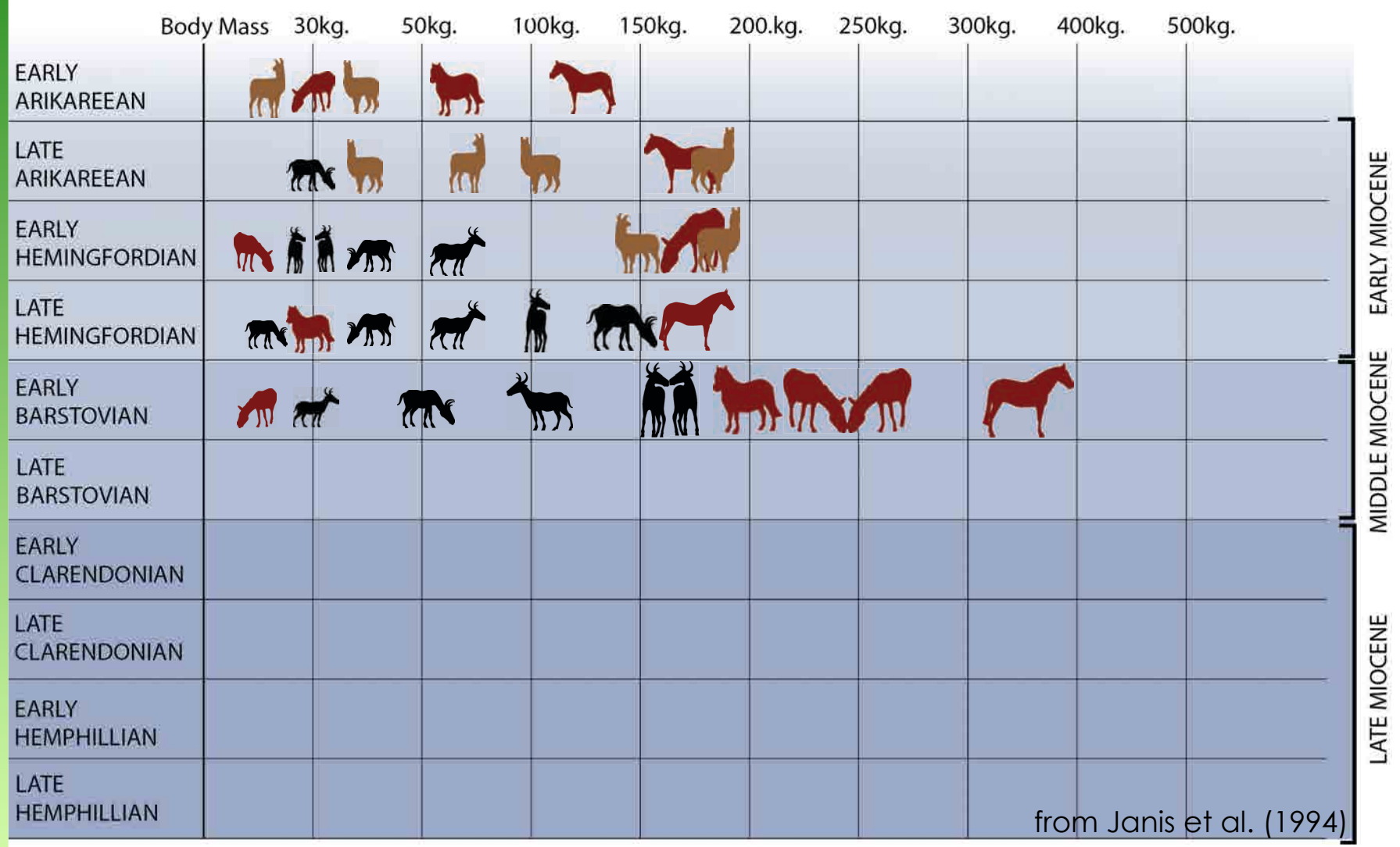

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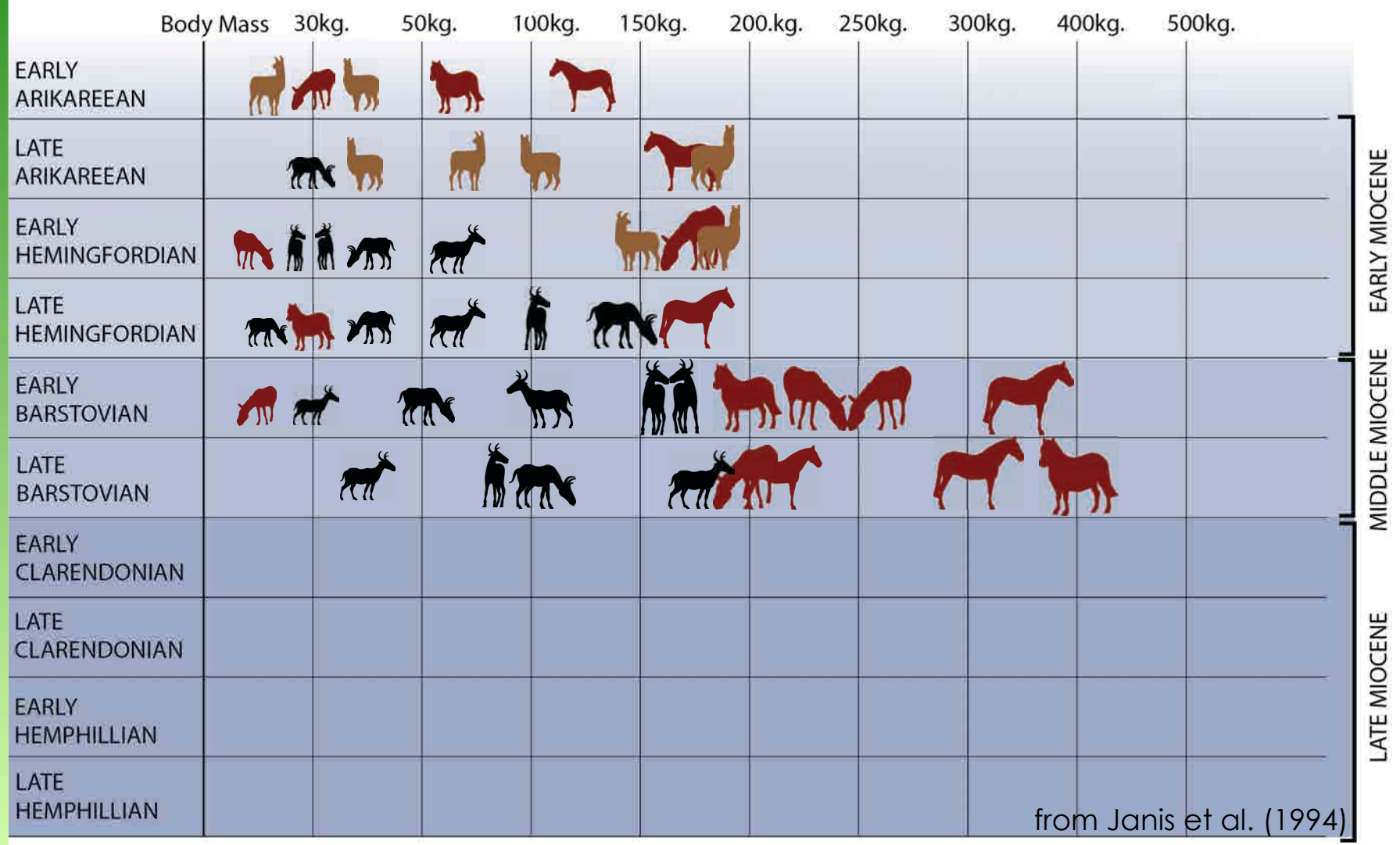

from Janis et al. (1994)

Question

Does more concrete evidence exist that camelids, as a taxonomic group, are characterised by a low level of metabolism?

Methods

1. Literature data: comparative food intake in camelids and domestic ruminants
   a) ad libitum food access
   b) roughage-only diets
   c) only studies that compared at least one camelid and one ruminant species in the same experiment

Methods

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   a) ad libitum food access
   b) roughage-only diets
   c) only studies that compared at least one camelid and one ruminant species in the same experiment

2. Oxygen consumption (chamber respirometry) in alpacas, llamas and Bactrian camels

Intake data

18 publications, 75 direct comparisons

Comparisons on the basis of

$kg^{0.75}$ $kg^{0.9}$ $kg^{1.0}$

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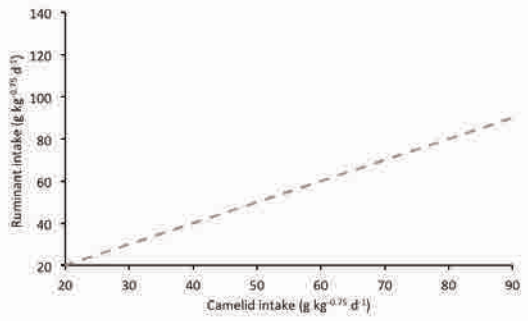

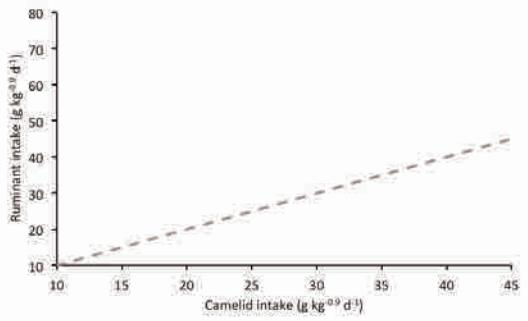

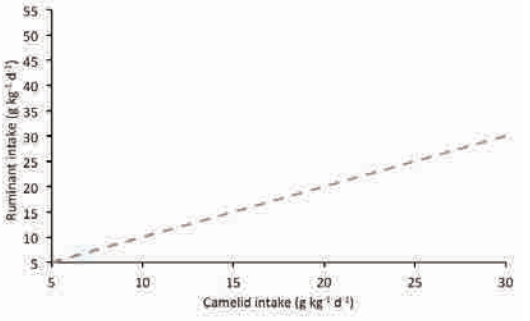

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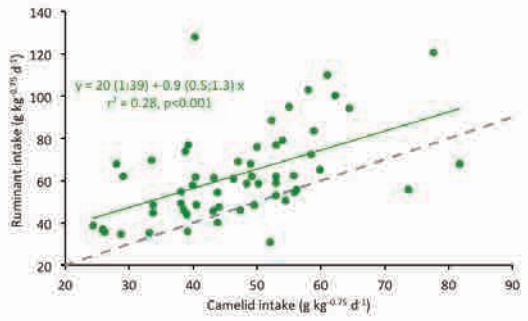

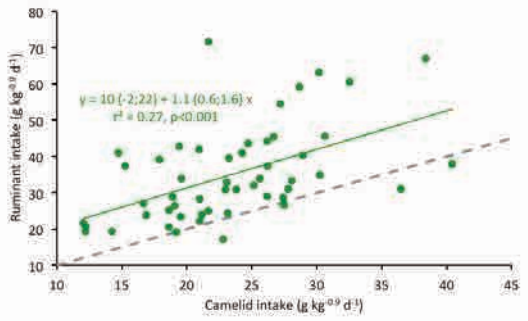

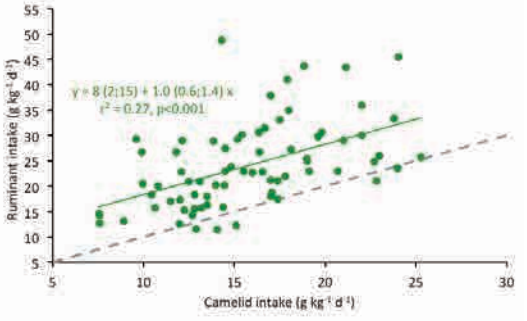

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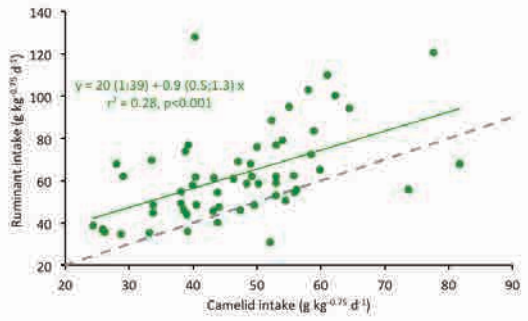

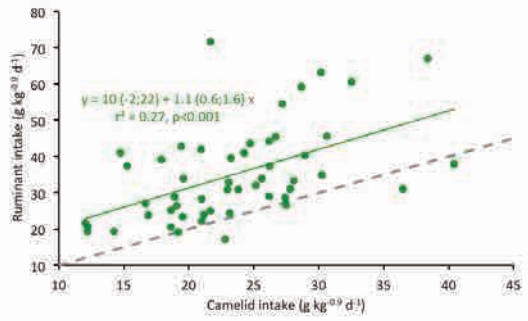

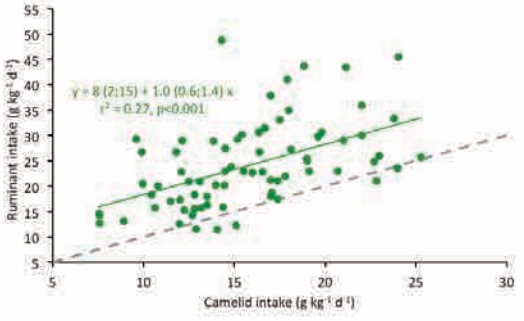

Ruminant intake higher by a factor of

1.4 ± 0.4 1.5 ± 0.5 1.6 ± 0.5

Respiration measurements

Respiration measurements

Respiration measurements

Respiration measurements

Respiration measurements

Respiration measurements

5 alpacas, 6 llamas, 5 Bactrian camels

constant access to food (lucerne) and water
measurements in winter

Portable pumps and analyser (Turbofox, Sable Systems)

O_2 x 20.08 J/L
all data = (maintenance) metabolic rate
20 lowest data points = resting metabolic rate

Camelid metabolism

Requirement	Species	Value	Reference
MEm	Goat	423-576 kJ $kg^{-0.75}$ d^{-1}	(GfE, 2003; NRC, 2007)
	Sheep	390-447 kJ $kg^{-0.75}$ d^{-1}	(GfE, 1996; NRC, 2007)
	Cattle	488-537 kJ $kg^{-0.75}$ d^{-1}	(GfE, 1995)

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Species	MEm	MR	Standing MR	Resting MR	Fasting MR	Source	Based on
	kJ $kg^{-0.75}$ day^{-1}						
SAC	305					(Van Saun, 2006; NRC, 2007)	Literature data
Alpaca	297					(Flores et al., 1989)	Cited in: (López and Raggi, 1992; San Martín, 1996)
Alpaca	276					(Newman and Paterson, 1994)	Intake & BM change
Alpaca	440					(Russel and Redden, 1997)	Intake & BM change
Llama	256					(Schneider et al., 1974; Rübsamen and von Engelhardt, 1975; von Engelhardt and Schneider, 1977)	Intake & BM change, chamber respirometry
Llama							
Llama							
Llama	310-354					(Carmean et al., 1992)	Chamber respirometry & heat production
Llama	296-343					(Vernet et al., 1997)	Chamber respirometry & heat production
Llama							
Dromedary							
Dromedary							
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Dromedary	359					(Farid et al., 1990)	Intake & BM change
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Llama			363			(El-Nouty et al., 1978)	Mask respirometry
Llama			341			(Hochachka et al., 1987)	Mask respirometry
Llama	310-354				248	(Carmean et al., 1992)	Chamber respirometry & heat production
Llama	296-343	313				(Vernet et al., 1997)	Chamber respirometry & heat production
Llama		290				(Nielsen et al., 2010)	Chamber respirometry
Dromedary				215		(Schmidt-Nielsen et al., 1967)	Mask respirometry
Dromedary				206		(Schmidt-Nielsen et al., 1981)	Mask respirometry
Dromedary			256	230		(Yousef et al., 1989)	Mask respirometry
Dromedary	359					(Farid et al., 1990)	Intake & BM change
Dromedary			216	203		(Evans et al., 1994)	Mask respirometry
Dromedary	374					(Farid, 1995)	Intake & BM change
Dromedary	304				213	(Guerouali et al., 1995)	Chamber respirometry & heat production
Dromedary			299			(Maloiy et al., 2009)	Mask respirometry

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Alpaca		**215**		**144**		**this study**	Chamber respirometry
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SAC	305					(Van Saun, 2006; NRC, 2007)	Literature data
Alpaca	297					(Flores et al., 1989)	Cited in: (López and Raggi, 1992; San Martín, 1996)
Alpaca	276					(Newman and Paterson, 1994)	Intake & BM change
Alpaca	440					(Russel and Redden, 1997)	Intake & BM change
Alpaca		**215**		**144**		**this study**	Chamber respirometry
Llama	256				218	(Schneider et al., 1974; Rübsamen and von Engelhardt, 1975; von Engelhardt and Schneider, 1977)	Intake & BM change, chamber respirometry
Llama			363			(El-Nouty et al., 1978)	Mask respirometry
Llama			341			(Hochachka et al., 1987)	Mask respirometry
Llama	310-354				248	(Carmean et al., 1992)	Chamber respirometry & heat production
Llama	296-343	313				(Vernet et al., 1997)	Chamber respirometry & heat production
Llama		290				(Nielsen et al., 2010)	Chamber respirometry
Llama		**261**		**164**		**this study**	Chamber respirometry
Dromedary				215		(Schmidt-Nielsen et al., 1967)	Mask respirometry
Dromedary				206		(Schmidt-Nielsen et al., 1981)	Mask respirometry
Dromedary			256	230		(Yousef et al., 1989)	Mask respirometry
Dromedary	359					(Farid et al., 1990)	Intake & BM change
Dromedary			216	203		(Evans et al., 1994)	Mask respirometry
Dromedary	374					(Farid, 1995)	Intake & BM change
Dromedary	304				213	(Guerouali et al., 1995)	Chamber respirometry & heat production
Dromedary			299			(Maloiy et al., 2009)	Mask respirometry

Camelid metabolism

Species	MEm	MR	Standing MR	Resting MR	Fasting MR	Source	Based on
	kJ $kg^{-0.75}$ day^{-1}						
SAC	305					(Van Saun, 2006; NRC, 2007)	Literature data
Alpaca	297					(Flores et al., 1989)	Cited in: (López and Raggi, 1992; San Martín, 1996)
Alpaca	276					(Newman and Paterson, 1994)	Intake & BM change
Alpaca	440					(Russel and Redden, 1997)	Intake & BM change
Alpaca		**215**		**144**		**this study**	Chamber respirometry
Llama	256				218	(Schneider et al., 1974; Rübsamen and von Engelhardt, 1975; von Engelhardt and Schneider, 1977)	Intake & BM change, chamber respirometry
Llama			363			(El-Nouty et al., 1978)	Mask respirometry
Llama			341			(Hochachka et al., 1987)	Mask respirometry
Llama	310-354				248	(Carmean et al., 1992)	Chamber respirometry & heat production
Llama	296-343	313				(Vernet et al., 1997)	Chamber respirometry & heat production
Llama		290				(Nielsen et al., 2010)	Chamber respirometry
Llama		**261**		**164**		**this study**	Chamber respirometry
Dromedary				215		(Schmidt-Nielsen et al., 1967)	Mask respirometry
Dromedary				206		(Schmidt-Nielsen et al., 1981)	Mask respirometry
Dromedary			256	230		(Yousef et al., 1989)	Mask respirometry
Dromedary	359					(Farid et al., 1990)	Intake & BM change
Dromedary			216	203		(Evans et al., 1994)	Mask respirometry
Dromedary	374					(Farid, 1995)	Intake & BM change
Dromedary	304				213	(Guerouali et al., 1995)	Chamber respirometry & heat production
Dromedary			299			(Maloiy et al., 2009)	Mask respirometry
Bactrian camel		**248**		**192**		**this study**	Chamber respirometry

Conclusions

Both ad libitum intake and maintenance energy recommendations/ metabolism measurements support a lower metabolism in camelids as compared to domestic ruminants.

This could explain various observations incl. the competitive capacity of camelids in resource-poor environments.

Distinct variability in metabolism measurements could be an indicator of methodological issues or seasonality effects.

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